# Harris Project

## EDSGN 100- Section 001

**Team 8**

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CONCEPT OF OPERATIONS (CONOPS) OUTLINE

# 1.0 INTRODUCTION

## 1.1 **Project Description**

The project consists of a functional military backpack that, through the applications of solar and kinetic energy, can recharge a handheld radio.

### 1.1.1 **Background**

The system is needed to supply a soldier with energy from alternative sources so that the soldier is capable of communicating with others when the radio's battery is low.

### 1.1.2 **Assumptions and Constraints**

Assumptions

- Availability of materials
- Legal rights

Constraints

- Government regulations
- Environmental limitations

## 1.2 **Overview of the Envisioned System**

### 1.2.1 **Overview**

The system consists of a backpack attached to a sliding panel that will gather kinetic energy. Solar panels are also placed at optimal positions to utilize solar energy.

### 1.2.2 **System Scope**

The system will be the size of a military backpack.

## 1.4 **Glossary**

Solar Energy- Energy derived from the Sun's radiation. Classified as passive or active.

Kinetic Energy- Energy generated as a result of motion. Kinetic energy can be harnessed as a form of alternative energy.

# 2.0 GOALS, OBJECTIVES AND RATIONAL FOR THE NEW SYSTEM

## 2.1 **Goals and Objectives of the New System**

The goal of the system is to provide eco-friendly energy to a radio for a soldier in combat. The system works by the backpack generating energy through solar and kinetic energy methods.

## 2.2 **Rationale for the New System (or Capability)**

The production of the system is justified because it is an efficient and renewable solution to recharge a radio's battery. The system will permit soldiers to always have the ability to communicate through their radios due to the recharging capabilities.

## 3.0 WORK PROCESSES TO BE AUTOMATED/SUPPORTED

The energy for the battery is drawn through solar power and kinetic power:

Solar- The solar energy is drawn from the sun through solar panels. The panels are wired to a portable charging device used to charge the lithium ion battery of the radio. While the sun is present, the radio will constantly be receiving energy. The solar panels will generate approximately 15 watts per hour and 75 watts per day. These calculations are based off of at least 5 hours of useable sunlight.

Kinetic- The kinetic energy is generated from a suspended load system. The suspended load system serves as the frame of the backpack. The weight of the backpack will slide up and down during travel. The moving load will turn the gears of a small generator attached to the suspended load frame. The kinetic aspect of the system generates 7.5 watts per hour.

## 4.0 HIGH-LEVEL FUNCTIONAL REQUIREMENTS

- The system shall feature: a military-grade backpack with suspended load frame system, flexible solar panels placed on the backpack and easily detached and stored and a diode drawing the energy produced from system and storing it in a charger.
- The diode shall interact with both the suspended load system and the solar panels. The charger shall interact with the diode through drawing the energy and the radio by charging it.

## 5.0 HIGH-LEVEL OPERATIONAL REQUIREMENTS

### 5.1 **Non-Functional Requirements**

- Performance: The system will perform through use of ambient solar power drawn from the sun and kinetic energy generated as a result of a traversing soldier.
- Accessibility: The system will be made accessible to a soldier through its existence as simple additions to a soldier's backpack. The charger should continuously gather energy to charge the radio so long as the soldier is in sunlight or moving with his backpack.
- Portability: All parts of the system are light enough for a soldier to carry. The combined impact of the weight of the suspended load system and solar panels will not hinder the soldier's movement. The solar panels are flexible and capable of being rolled up and stored with ease.

### 5.4 **System Environment**

The system shall operate in environments with sunny conditions so that the solar panels may produce substantial energy. The soldier should also be in an environment in which he/she may move frequently so as to gather energy through the kinetic system.

## 6.0 USER CLASSES AND MODES OF OPERATION

### 6.1 **Classes/Categories of Users**

As our use case states, the users of the system will consist of soldiers out in the field in sunny conditions and who will also be carry backpacks frequently.

### 6.2 **User Classes Mapped to Functional Features**

Size of the backpack will vary for soldiers who carry more or less materials, but the backpacks will be produce only for soldiers with backpacks and radios in the field, at this moment.

### 6.3 **Sample Operational Scenarios**

An example of a scenario for the use of our system is a situation in which a soldier is in need of contact fellow troops with his radio, but his radio's battery has died. The soldier, through our system, would be capable of charging his radio with the energy our system has harnessed during his travels and time in the sun with his backpack.

## 7.0 IMPACT CONSIDERATIONS

### 7.1 **Operational and Organizational Impacts**

Our system would impact existing radio chargers and give added opportunities to soldiers in the field due to the extended life of their radio's battery.

### 7.2 **Potential Risks and Issues**

- Durability: A potential risk exists in regard to the durability of the system. The system should be able to withstand war conditions, given that it is cared for properly.
- Appearance: The solar panels attached to the backpack should have special care given to them. The solar panels should be maintained so as to keep their camouflaged appearance and not give away the soldier's position.

**Use Case:**

Our use case is a soldier in the middle of the desert who needs to operate a radio from the energy produced by renewable and portable energy sources. We chose a soldier in the middle of a dessert as it matches with the scenario in today's world; the United States is having constant conflicts with Middle Eastern Countries and the soldiers are forced to fight in deserts where they might run out of battery in their radio if they do not have proper and efficient charging systems.

We choose this use scenario also because it is one of the most extreme scenarios the soldier will face and if our system works well in these conditions it should work well in any.

**Our customer need analysis is as follows:**

1. Our charging system should produce should produce enough energy to keep the radio running constantly.
2. Our charging system should be easy to operate so that the soldiers don't have a tough time charging their radio while they are facing the enemy.

3. Our charging system should not affect the soldier's performance in battle (i.e. it should not be very heavy, it can't be flashy so that it comes in the eyes of the enemy, it should blend with the dress of the soldier and not be a problem for him to carry around-camoflouge).

4. Our charging system should be environmentally friendly so that our target of making a renewable charging system is not neglected. Because if we produce an energy efficient system that affects the environment our target would go in vain.

**Target specifications:**

Our goal is to keep a radio continuously running -radio uses at most 80 watts/day- so we must produce at <u>least</u> this if not more. We chose 80 because that is a very extreme number. If we can produce 80 watts/day on average, we can easily charge a radio.

Produce this 80 watts/day only using renewable energy.

**Benchmarking:**

<u>Solar Power</u>

Used a 6V 2W panel and a 10V 1.3W panel, connected in parallel using a modified 3-panel circuit box. The device charged was a completely drained V11 battery pack.

Means that it is ok to combine panels of different Voltages together as long as they are roughly similar and they don't fall outside of the specifications of the device you're charging. The Voltage of the combined panels drop to whatever the load requires to charge and the POWER output of both panels on their own is roughly additive.

<u>Kinetic Power</u>

Kinetic energy is power that is gained from motion, and this motion can involve vehicles, individuals, and other objects or organisms. Another way of generating green electricity is to use solar panels for electricity generation. Alternative power sources are an important part of meeting the energy needs of the future, because at some point fossil fuels will become scarce, and kinetic energy as renewable energy is clean and ecofriendly. As time goes on these fuels and power resources will cost less than fossil fuels do, and they will be readily available as well. Generating green electricity does not have to be extremely expensive, and you can make solar panels for electricity generation instead of buying them to save money. Windmills use kinetic energy, and so do some hydro methods as well. This alternative power source has been used through history, and it is becoming extremely popular again today. Renewable alternative energy sources are becoming more in demand, and many states and areas have laws in effect that allow you to sell any excess power generate to the utility company. Installing devices which will be generating green electricity can be a great idea, especially if you want to lower your utility costs or even eliminate them completely. A combination of methods can be used, including windmills, solar panels, water sources, and others to make your home very efficient and more environmentally friendly.

Nanofibers

Nanotechnology is providing new solutions and opportunities to ensure sustainable energy and environments for the future. Materials of nanofiberous morphology are attractive to solve numerous energy and environmental issues. Nanofibers can be effectively produced by electrospinning, which is a simple and low cost technique. In addition, electrospinning allows the production of nanofibers from various materials e.g. organics and inorganics in different configurations and assemblies. This is highly beneficial for energy devices, where inorganic materials especially metal oxides can be synthesized and electrospun, improving conducting and ceramic properties. Excitonic solar cells fabricated with aligned nanofiberous metal oxide electrodes provide higher solar–electric energy conversion efficiency, whereas fuel cells made with nanofiberous electrodes enable uniform dispersion of catalysts, and thus increase electrocatalytic activity to obtain higher chemical–electric energy conversion efficiency. The nanofibers used in filtration membranes for environmental remediation, minimize the pressure drop and provide better efficiency than conventional fiber mats. The large surface area-to-volume ratio of nanofiber membranes allows greater surface adsorption of contaminants from air and water, and increases the life-time of the filtration media. This review highlights the potential and application of electrospun nanofiberous materials for solving critical energy and environmental issue.

Friction

When surfaces in contact move relative to each other, the friction between the two surfaces converts kinetic energy into heat. This property can have dramatic consequences, as illustrated by the use of friction created by rubbing pieces of wood together to start a fire. Kinetic energy is converted to heat whenever motion with friction occurs, for example when a viscous fluid is stirred. Another important consequence of many types of friction can be wear, which may lead to performance degradation and/or damage to components. Friction is a component of the science of tribology.

Friction is not itself a fundamental force but arises from fundamental electromagnetic forces between the charged particles constituting the two contacting surfaces. The complexity of these interactions makes the calculation of friction from first principles impossible and necessitates the use of empirical methods for analysis and the development of theory.

**Concept generation and Selection:**

We came up with 5 concepts that would be appropriate for the project and would satisfy the requirements set before us by the Harris Company.

-Solar panels which uses the sun to generate energy

-Body back which uses body heat to generate energy

-Friction panels which can be either manually slid or slid as a result of walking, this will generate energy

-Clothes out of Nano fibers that create electricity when you move around

-Hand Crank

| | | Energy Concepts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Solar | | Kinetic | | Body Heat | | Nanofibers | | Friction | |
| Criteria | Weight | Rating | Weighted Score | Rating | Weighted Score | Rating | Weighted Score | Rating | Weighted Score | Rating | Weighted Score |
| Ease of Use | 45% | 5 | 2.25 | 4 | 1.8 | 2 | 0.9 | 3 | 1.35 | 4 | 1.8 |
| Reliability | 35% | 4 | 1.4 | 5 | 1.75 | 4 | 1.4 | 3 | 0.7 | 4 | 1.4 |
| Cost | 20% | 4 | 0.8 | 5 | 1 | 3 | 0.6 | 2 | 0.4 | 3 | 0.6 |
| Sum/Rank | 100% | 13 | 4.45 | 14 | 4.55 | 9 | 2.9 | 8 | 2.45 | 11 | 3.8 |

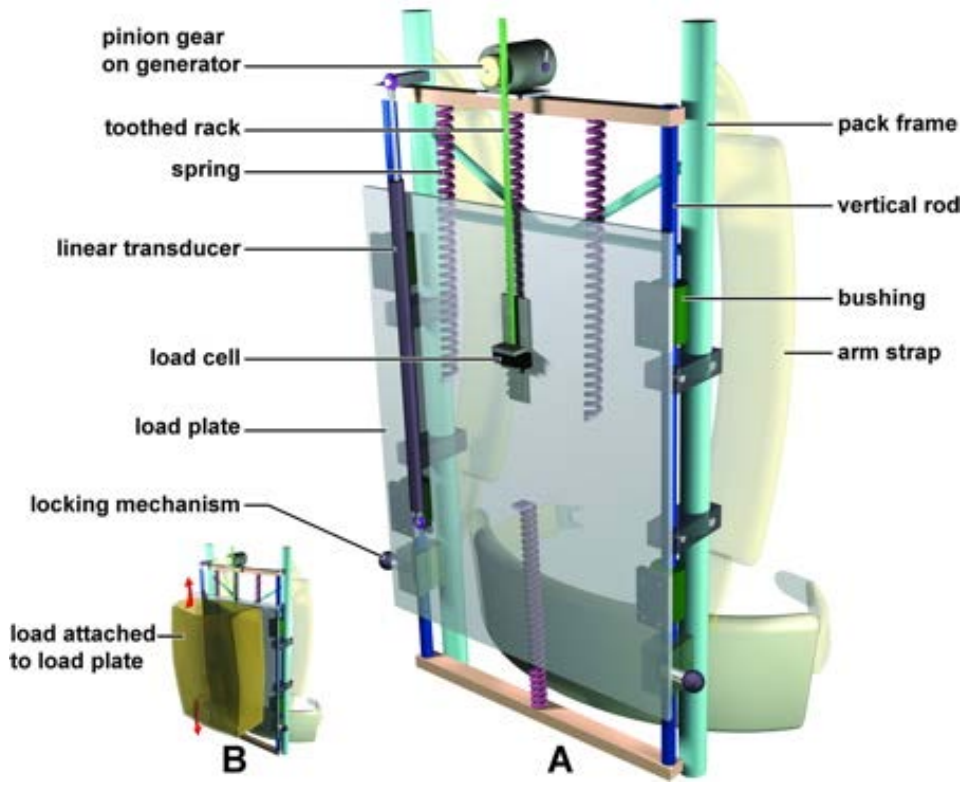
For our decision on which two components of renewable energy we wanted to use we created a chart weighing the scores of the energy against one another and we decided on using **kinetic** and **solar** power because they received the highest overall rating in our concept generation matrices.

**Solar Power Source:**

In the design of our system, the solar panels drape over the bag pack and cover it completely. It will be around 1.5 square feet in area. The solar panels will have a wire which meets up with our charging hub (which contains lithium ion battery). The solar panel can be folded up when it is not in use, which makes our design highly ideal for longer durability. One will be able to completely disconnect (remove) the solar panels from the backpack if needed. The solar panels' wire/chord which connects the solar panel system to the charger itself will be able to be unplugged also as needed. On average, modern photovoltaic (PV) solar panels will produce 8 - 10 watts per square foot of solar panel area. Considering our solar panel area of 1.5 square feet and 5 hours of considerable sun light, our solar power source should produce around 15 watts/hour (1.5 X 10) and 75 watts/day (15 X 5).

## Kinetic Power Source:

For the Kinetic Power Source to our charger we used a system which will be referred to as a suspended load system. As humans walk their hips move vertically a distance of around 2-3 inches (5-7 cm) on average as they take each step. As seen in the image below, the load (where soldier places supplies) is separated from the frame. The frame lies on the persons back while the load is suspended from the frame by vertical springs. The load moves up and down as the person walks due to hip movement, but lags behind the motion of the hip slightly. The differential movement between the frame and the load is what generates energy and electricity. The up and down movement of the load turns a gear (shown below) which is connected to a generator. Coils of wire within a magnetic field are rotated inside the generator creating electricity. A chord goes from the generator to the charger itself. This allows the suspended load system to help charge the charger along with the solar panel system. The chord connecting the charger to the kinetic system (suspended load system) can be unplugged /disconnected if needed. This system generates 7.5 watts of electricity after an hour of walking. Considering soldiers walk a very large amount and carry heavy loads by trait, generating electricity through this suspended load system should be easy.




**Overall Design:**

Overall our total system includes the following two parts: 1) the charging system, which is made up of the suspended load system, solar panel system, and charger 2) the actual radio/communication device itself. The solar panel system and kinetic system are connected along with a diode to the charger. The charger, which contains a lithium-ion battery, can be found in an inside pouch in the load (part of the suspended load system). The solar and kinetic systems can be unplugged from the charger at any point. The charger can then be removed from the pouch and load. Thus, the charger is portable. It can be removed and carried separately at any point. The radio can plug in and charge from the portable charger (just as a phone would plug in and charge from a portable laptop). The radio can charge from the charger either when the charger is connected to the power sources (solar and kinetic) or when it is separate and portable.

As mentioned before the solar panel system can be disconnected from charger. The solar panels (which drape over the load portion of the suspended load system) can also be disconnected from the load if need be. The solar panels can also fold up for extra convenience. The solar panels can be removed and placed in the backpack if the user wishes to (i.e. user is going into combat and feels no need for them). They can also be removed and spread out on a flat surface.

The suspended load system can be disconnected from the charger as well. The user can do whichever he/she desires.

**Issues of safety, economic viability, environmental impact:**

Our final product is a lightning bag pack in combination with a solar panel, so our device has no issues of safety as all the wires and internal and compact, and we have a fuse which breaks up the circuit of our charging in case of overheating or any sort of malfunction so our device poses no harm to the soldiers.

Our product is pretty much economically viable as there is not a lot of spending to be done our entire system costs about 365$ and produces energy up to 112.5 watt/day (assuming 5 hours of sunlight and 5 hours of walking) and a radio uses just about 80 watt/day. Also our system is highly durable. By the above values it can be concluded that our device is a best fit in terms of economic viability.

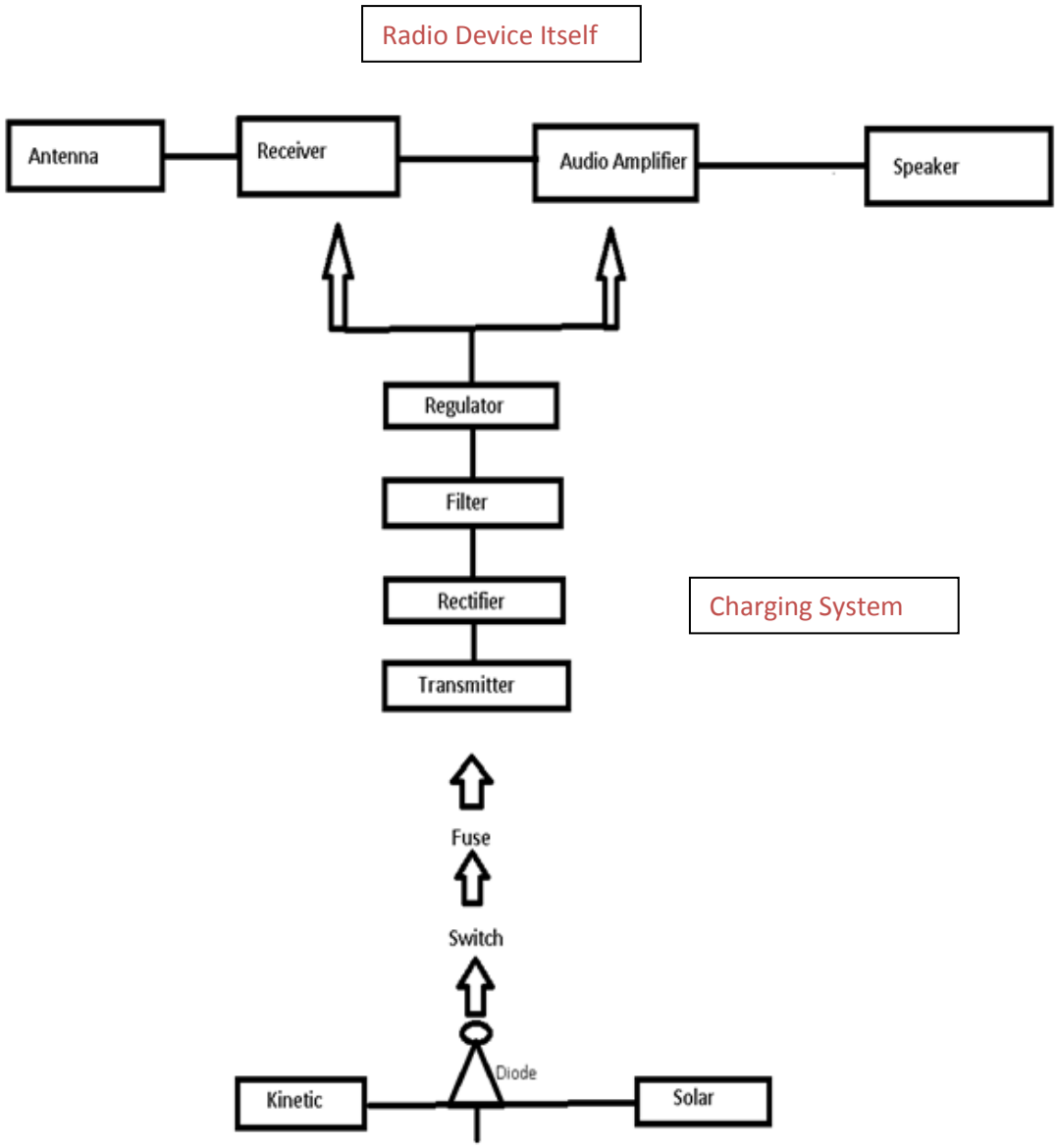
Lastly, our system doesn't has any effect on the environment because all we use is a bag pack, solar panels and a few electrical devices. A bag pack can also be recycled and re-used, solar panels last pretty long and similar is the case with the electronic devices.

**Total Energy Produced:**

Our solar power system generates around 75 watts/day as mentioned previously, while our suspended load system generates 7.5 watts of electricity as mentioned before after an hour of walking.

**Block Diagram:**

We created the following block diagram for our sytem. Our kinetic power source (suspended load system) , comes together with our solar power source (PV system) via a diode. The diode prevents dissipation from one power source (kinetic) to another (solar). The top, horizontal portion of the block diagram represents the radio device itself while everything below represents the entire charging system (solar panels, suspended load system, and charger itself). Together the charging system and the radio device make up our entire system.



**Costs:**

The costs of our system will be funded by the military as defined in our use case but to be economically sound our systems costs are:

(Kinetic) Suspended load system –300$

Solar panels-65$

Charger system (solar panel+ load system)-365$

If we are to conclude the cost of the radio in our estimates which is around a hundred dollars our total for the complete package of the suspended load system, radio, and solar panels comes out to about 465$ and is affordable on almost anyone's budget but seeing as many people don't have a need for charging electronics on the move our system will be bought and used by mainly military and hiking and backpacking enthusiasts.

**Conclusion:**

In conclusion, our system generates 75 watts a day plus 7.5 watts of electricity from walking. Considering most radios consume far less than 75 watts/day, our system should easily charge a radio. Our solar panels alone should generate enough electricity and beyond for a typical radio. Plus we still have our suspended load system to provide us with even more electricity. The solar and kinetic systems together help us clearly meet our target specifications of 80 watts/day. Together they create enough energy for even the worst of situations, and they are completely renewable.

**References:**


http://voltaicsystems.com/blog/combining-non-matched-power-sources

http://www.solar-estimate.org/?page=solar-calculations

http://www.lightningpacks.com/

http://news.nationalgeographic.com/news/2005/09/0908_050908_backpack_2.html

http://phys.org/news122129780.html

http://hyperphysics.phy-astr.gsu.edu/hbase/ke.html

http://www.solarenergy.com/

http://batteryuniversity.com/

http://www.nationalatlas.gov/articles/people/a_energy.html